4,5,15,16

PTO 04-1234

Japanese Patent

Document No. H06-53875

SATELLITE CHANNEL ACCESS SYSTEM

[Eisei Chaneru Akusesu Shisutemu]

Yukari Kokufu

UNITED STATES PATENT AND TRADEMARK OFFICE

Washington, D.C. December 2003

Translated by: Schreiber Translations, Inc.

Country	:	Japan
Document No.	:	H06-53875
Document Type	:	Kokai
Language	:	Japanese
Inventor	:	Yukari Kokufu
Applicant	:	NEC Corp.
IPC	:	H 04 B 7/212
Application Date	:	July 29, 1992
Publication Date	:	February 25, 1994
Foreign Language Title	:	Eisei Chaneru Akusesu Shisutemu
English Title	:	SATELLITE CHANNEL ACCESS SYSTEM

(54) Title of the invention

Satellite channel access system

(57) Summary

Objective: In the time division multiple connection channel access format, the number of time slots used for transferring an invariable volume of data is reduced for the purpose of improving the line utility efficiency.

Constitution: In a case where multiple data coded by the slotted Aloha format mutually collide due to line congestion and/or where large numbers of data have come to stagnate within a peripheral station with regard to an embodiment in which the slotted Aloha format and the slot reservation format are jointly used in the time division multiple connection channel access format, the number of time slots used for transferring an invariable volume of data can be reduced by adding only one header to the multiple data and by collectively transmitting [said data] to a single reserved slot in comparison with a case where a single time slot is accessed by the data one by one. In the case of a long datum that covers several time slots, furthermore, it is transmitted in undivided states to a single reserved slot for the purpose of avoiding an overhead gain attributed to packet division.

[1] Numbers in the margin indicate pagination in the foreign text.

Patent Claims /2

Claim 1

A satellite channel access system with the following characteristics: In a satellite channel access system of the time division multiple connection format which, in a case where a central station is accessed by multiple peripheral stations via a communications satellite by using a common channel in a time-divided fashion, jointly uses, as formats whereby all the peripheral stations access time slots that serve as time division units of the aforementioned channel, a slotted Aloha format that permits random access and a slot reservation format that uses a special time slot reserved in advance,

The reserved time slot is of a format which involves multiple consecutive time slots, whereas,

In a case where multiple transmission data have come to stagnate within a single peripheral station, such multiple data are transmitted based on a format whereby only a single header unit has been added to them on one of the aforementioned reserved time slots.

Claim 2

A satellite channel access system with the following characteristics: In a satellite channel access system of the time division multiple connection format which, in a case where a central station is accessed by multiple peripheral stations via a communications satellite by using a common channel in a time-divided fashion, jointly uses, as formats whereby all the

peripheral stations access time slots that serve as time division units of the aforementioned channel, a slotted Aloha format that permits random access and a slot reservation format that uses a special time slot reserved in advance,

The reserved time slot is of a format which involves multiple consecutive time slots, whereas,

In a case where a single transmission datum the length of which covers multiple time slots has become generated, said single transmission datum is transmitted based on a format whereby only a single header unit has been added to it on one of the aforementioned reserved time slots.

Claim 3

A satellite channel access system with the following characteristics: In a satellite channel access system of the time division multiple connection format which, in a case where a central station is accessed by multiple peripheral stations via a communications satellite by using a common channel in a time-divided fashion, jointly uses, as formats whereby all the peripheral stations access time slots that serve as time division units of the aforementioned channel, a slotted Aloha format that permits random access and a slot reservation format that uses a special time slot reserved in advance,

The reserved time slot is of a format which involves multiple consecutive time slots, whereas,

Each of the aforementioned peripheral stations possesses

A mechanism which not only determines, in accordance with the number of transmission data stagnating within said station itself and the lengths of the respective transmission data, the length of the aforementioned reserved time slot necessary for transmitting such transmission data but also determines the number of the aforementioned transmission data to be collectively transmitted to the aforementioned reserved time slot assigned to said station itself and

A mechanism which converts, based on the obtained determination results, the aforementioned transmission data into packets that share a single header, whereas

The aforementioned central station includes

A mechanism which, by acknowledging the individual transmission data which have become transmitted to one of the aforementioned reserved slots, detects transmission errors for each of the individual data thus acknowledged and

A mechanism which generates a response signal for confirming the receptions of the aforementioned individual data and then transmits the same to the peripheral stations of their transmission sources.

Detailed explanation of the invention

[0001]

(Technical fields)

The present invention concerns a satellite channel access system, and in particular, it concerns a satellite channel access system of the time division multiple connection format which executes communications between a central station and multiple peripheral stations via a communications satellite.

[0002]

(Prior art)

The first example of the TDMA channel access format whereby a single satellite line is shared, in a time-divided fashion, by multiple stations (peripheral stations) and whereby said stations communicate with a single central station based on the time division multiple connection format, is the slotted Aloha format. This slotted Aloha format permits all the peripheral stations to randomly access time slots, namely terminals obtained by time-dividing the satellite line, and to transmit packet data. This format is advantageous in that it enables a transmission with a minimal delay in a case where the message occurrence rate is low. In a case where the line becomes congested in this format, however, multiple data often collide with one another, as the time chart of Figure 13 indicates, and since a phenomenon whereby the data repeatedly collide becomes unavoidable, as in the case of the datum <2> and datum <5> in the figure, the entire system becomes unstable. Incidentally, the hatched portions at the tops of the respective data <1> ~ <5> in the figure signify headers.

[0003]

The second example of the TDMA channel access format is the slot reservation format. According to this format, data required for peripheral stations in the context of reserving slots are initially transmitted based on random access, in response to which a central station assigns slots specific to the respective peripheral stations. This format is advantageous in that stable and flexible responses are possible in a case where the message occurrence rate is relatively high or where the occurrence rate variation is significant. In a case where the message occurrence rate is low, however, it is problematic in that the delay magnitude is more substantial than that of the random access format (slotted Aloha format).

[0004]

The third format is the random access & reservation composite format which represents a composite of the first and second formats. According to this format, the utilities of the random access format and slot reservation format are differentiated depending on the message occurrence statuses. Actions, for example, are normally invoked based on the simple slotted Aloha format, but actions become invoked based on the slot reservation format in a case where multiple retransmission data have come to stagnate within a peripheral station due to a line congestion and frequent collisions or where large numbers of messages arise within a single peripheral station simultaneously.

[0005]

The time chart shown in Figure 14 instantiates the random access & reservation composite format. In a case where data have come to collide with one another as a result of line congestion and where multiple retransmission data have arisen within a peripheral station, the slot reservation format is used for transmitting the retransmission data. In the example shown in this figure, slots are reserved not only for the retransmission data but also for the data <4> and <5>, which have become generated anew from the terminal prior to the transmission of the retransmission data <1> after reservation requests have been added to them. It is thus that the transmission of data based on random access becomes inhibited and that the instability of the system can be avoided.

[0006] /3

The time chart shown in Figure 15 instantiates the second example of the random access & reservation composite format. In this example, a message with an extended data length generated within a peripheral station is divided into packets by designating, as a division unit, the data length that can be transmitted via a single time slot, and only the packet at the top becomes transmitted based on random access for a reservation request, whereas the subsequent packets are transmitted by using the assigned slots.

[0007]

As Figures 13 ~ 15 show, furthermore, headers indicated by hatched segments are added respectively to the individual data in

a case where they become transmitted to the satellite line. Such a header is constituted by a preambling unit for reproducing carrier waves and clocks, addresses for peripheral stations, redundant bits for detecting transmission errors, etc. If the length of a message issued from the terminal is short enough to be stored within a single time slot of the satellite line, the header is added to each message and then transmitted as a single packet datum by using a single time slot.

[0008]

If the length of a message issued from the terminal is not short enough to be stored within a single time slot, furthermore, it is divided into several packets, and after a header has been added to each of these packets, each packet is transmitted by using a single time slot. This protocol is common to the random access format (slotted Aloha format), slot reservation format, and the random access & reservation composite format.

[0009]

As Figures 13 and 14 show, the lengths of data generated from a terminal are zone & zone [sic: Presumably "are diverse?"], and in a case where [the combined] lengths of the data and header are shorter than the time slot length, the remainder becomes filled with dummy bits. In a case where the data <1>, <2>, <3>, and <4> of Figure 14 are transmitted, the slot is longer than the [combined] lengths of the actual data and header, and therefore, the last portion of the slot is filled with dummy bits. In a case where the individual [1 & 1] data are shorter than the slot

length, the use of a single slot by the individual [1 & 1] data entails a line efficiency loss, and at the same time, since large numbers of slots are used, it contributes to the aggravation of the line congestion.

[0010]

As Figure 15 shows, furthermore, in a case where a long message is divided into packets, it is necessary to add a header to each individual packet. Since the header portion is sizable in the case of satellite communications, the ratio of the header portion in relation to the actual message generated from the terminal is high. For this reason, the line efficiency diminishes.

[0011]

(Objective of the invention)

The objective of the present invention is to provide a satellite channel access system which is capable of improving the line utility efficiency by minimizing the number of time slots used for data transfer as much as possible.

[0012]

(Constitution of the invention)

One satellite channel access system of the present invention is characterized as follows: In a satellite channel access system of the time division multiple connection format which, in a case where a central station is accessed by multiple peripheral

stations via a communications satellite by using a common channel in a time-divided fashion, jointly uses, as formats whereby all the peripheral stations access time slots that serve as time division units of the aforementioned channel, a slotted Aloha format that permits random access and a slot reservation format that uses a special time slot reserved in advance,

The reserved time slot is of a format which involves multiple consecutive time slots, whereas,

In a case where multiple transmission data have come to stagnate within a single peripheral station, such multiple data are transmitted based on a format whereby only a single header unit has been added to them on one of the aforementioned reserved time slots.

[0013]

Another satellite channel access system of the present invention is characterized as follows: In a satellite channel access system of the time division multiple connection format which, in a case where a central station is accessed by multiple peripheral stations via a communications satellite by using a common channel in a time-divided fashion, jointly uses, as formats whereby all the peripheral stations access time slots that serve as time division units of the aforementioned channel, a slotted Aloha format that permits random access and a slot reservation format that uses a special time slot reserved in advance,

The reserved time slot is of a format which involves multiple consecutive time slots, whereas,

In a case where a single transmission datum the length of which covers multiple time slots has become generated, said single transmission datum is transmitted based on a format whereby only a single header unit has been added to it on one of the aforementioned reserved time slots.

[0014]

Still another satellite channel access system of the present invention is characterized as follows: In a satellite channel access system of the time division multiple connection format which, in a case where a central station is accessed by multiple peripheral stations via a communications satellite by using a common channel in a time-divided fashion, jointly uses, as formats whereby all the peripheral stations access time slots that serve as time division units of the aforementioned channel, a slotted Aloha format that permits random access and a slot reservation format that uses a special time slot reserved in advance,

The reserved time slot is of a format which involves multiple consecutive time slots, whereas,

Each of the aforementioned peripheral stations possesses

A mechanism which not only determines, in accordance with the number of transmission data stagnating within said station itself and the lengths of the respective transmission data, the length of the aforementioned reserved time slot necessary for transmitting such transmission data but also determines the number of the aforementioned transmission data to be collectively transmitted to

the aforementioned reserved time slot assigned to said station itself and

A mechanism which converts, based on the obtained determination results, the aforementioned transmission data into packets that share a single header, whereas

The aforementioned central station includes

A mechanism which, by acknowledging the individual transmission data which have become transmitted to one of the aforementioned reserved slots, detects transmission errors for each of the individual data thus acknowledged and

A mechanism which generates a response signal for confirming the receptions of the aforementioned individual data and then transmits the same to the peripheral stations of their transmission sources.

[0015]

(Application examples)

In the following, application examples of the present invention will be explained in detail with reference to figures.

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[0016]

Figure 1 is a diagram which shows a constitutional example of a satellite communications network to which an application example of the present invention has been applied. This satellite communications network is constituted by a single central station (C) and multiple peripheral stations (T1), (T2), ..., whereas said

peripheral stations (T1), (T2), ... access the central station (C) by time-dividing a single channel via the satellite (S). A starry network is realized by connecting a host terminal to the central station (C) and by connecting user terminals to the respective peripheral stations (T1), (T2), ...

[0017]

Figure 2 shows a format for signals directed from the peripheral stations (T1), (T2), ... to the central station (C). In a case where signals are transmitted from the peripheral stations (T1), (T2), ... to the central station (C), a single channel is initially divided into frames of an invariable temporal duration, and after each frame has been further divided into several time slots, said time slot is designated as a fundamental transmission unit. In the example of Figure 2, a single frame is divided into 8 slots. Sequence Nos., furthermore, are assigned to these frames, and the acknowledgments of these Nos. mutually coincide between the central station (C) and the peripheral stations (T1), (T2), ...

[0018]

The packet data transmitted from the peripheral stations (T1), (T2), ... to the central station (C) are fundamentally characterized by the format shown in Figure 2. All the packet data transmitted based on the random access format (slotted Aloha format) must comply with this format of Figure 2.

[0019]

In other words, the following are provided as constituent units: The overhead unit (OH) comprised of a preambling unit for reproducing carrier waves & clocks, a unique word unit which indicates the beginning of data, the field (ADRS), which shows the peripheral station address of the transmission source, the field (REQ), which shows the length of a requested reservation slot, the packet order No. (SEQ), which has been transmitted by each peripheral station, the field (COUNT), which shows the number of data units included in said packet, the frame check sequence field (FCS1), which serves a function of detecting transmission errors from the ADRS unit to the COUNT unit, the data unit (UNIT), in which a single message issued from a terminal is stored, dummy bits for matching the packet length with the length of a single time slot, redundancy bits (FEC) for correcting errors, and the guard time (GT), which serves a function of securing an interval with the packet to be transmitted to the next slot.

[0020]

Of these, the data unit (UNIT) is constituted by the message (DATA) issued from the terminal, the information field (PC), which, in a case where a single message has been divided into multiple packets at a peripheral station, serves a function of assembling said packets into the single message once again at the central station, the field (PL), which shows the length of said message, and the frame check sequence field (FCS2), which targets the PL unit, PC unit, and the DATA unit.

[0021]

In a case where a packet which uses the format of Figure 2 becomes transmitted based on the random access format, "0" becomes designated in the COUNT unit. Likewise, in a case where a packet which uses the format of Figure 2 becomes transmitted to a reserved slot, "1" becomes designated in the COUNT unit.

[0022]

The respective lengths of the OH unit, ADRS unit, REQ unit, SEQ unit, COUNT unit, FCS1 unit, FEC unit, and the GT unit are each fixed, and therefore, the maximal length of the data unit that can be stored within a single time slot is determined by default. The respective lengths of the PL unit and PC unit are also invariable, based on which the maximal length L_{max} of the message that can be stored within a single time slot is also determined by default.

[0023]

In a case where the length of a message issued from a terminal is lesser than this maximal length L_{max}, said message becomes stored in a packet of the format shown in Figure 2 and then transmitted to one arbitrary time slot based on the random access format (slotted Aloha format).

[0024]

Figure 3 shows a format for signals directed from the central station to the peripheral stations (T1), (T2), ... Not only does the central station (C) transmit packet data to the peripheral stations (T1), (T2), ..., but it also transmits, based on the broadcast mode, a frame timing signal which shows the boundaries

of a frame of an invariable temporal duration. This frame timing signal serves as a timing standard in a case where signals are transmitted from the peripheral stations (T1), (T2), ... themselves, and the interval for transmitting this frame timing signal is equal to the length of the frame obtained as a result of the time division of the channel during the transmissions of the peripheral stations (T1), (T2), ... The central station (C), furthermore, transmits a frame timing signal of a special pattern which shows the timing of frame No. 0 at a constant periodic frequency (e.g., once every 16 frames or once every 128 frames) as a standard for matching the acknowledgments of frame Nos. between the central station (C) and the respective peripheral stations.

[0025]

Following the frame timing signal, the central station (C) transmits, based on the broadcast mode, a reception response signal for the data transmitted by the peripheral stations (T1), (T2), ... based on the random access format. Said reception response signal is formulated by laying out the transmission source peripheral station addresses of the data authentically received by the central station (C) in the order of slots, and "0" is all [in verbatim] encoded with regard to slots which have received no data or slots which have failed to receive data normally due to collisions among data or transmission errors, etc. With regard to this reception response signal, the reserved slot assigned to any given peripheral station is regarded to be

equivalent to the slot which has received no data, and "0" is all encoded.

[0026]

Following the reception response signal, furthermore, the central station (C) transmits, based on the broadcast mode, slot assignment broadcast information. The slot assignment broadcast information represents information that indicates whether the respective time slots of a given frame are slots which permit random access or slots assigned to any of the peripheral stations. In the example of Figure 3, the slot <1> and the slots <5> ~ <8> are randomly accessible slots, whereas the slots <2> ~ <4> are slots assigned to some peripheral stations.

[0027] /5

Both the reception response signal and slot assignment broadcast information are transmitted by designating a single frame as a transmission unit. The relationships of the reception response signal and slot assignment broadcast information transmitted by the central station (C) with frames that provide transmission timing standards for the peripheral stations (T1), (T2), ... are graphically shown in Figure 16.

[0028]

According to Figure 16, the satellite delay is assumed to be equivalent to a single time slot, whereas a single frame is divided into 8 time slots. The peripheral station (T1) transmits, by using the slots <2>, <4>, and <7> of Frame 1, three packets. Collisions among data, however, have arisen within the slot <4>.

Another peripheral station, namely T2, furthermore, is assumed to have transmitted a single packet by using the slot <6> of the same Frame 1.

[0029]

Immediately after the completion of Frame 1, the central station (C) formulates and transmits a reception response signal. As far as the contents of the concomitantly prevailing reception response signal are concerned, the address of the peripheral station (T1) is encoded into the respective positions of the slots <2> and <7>, whereas the address of the peripheral stations (T2) is encoded into the position of the slot <6>, whereas "0" is all encoded into the remaining slots.

[0030]

The reception response signal corresponding to Frame 1 is assumed to arrive, midway toward Frame 2, at a peripheral station without fail. The slot assignment broadcast information transmitted together with this reception response signal, furthermore, is the slot assignment information on Frame 3. According to this slot assignment information, the slots <2> ~ <4> of Frame 3 are each reserved slots assigned to some peripheral stations. For this reason, the peripheral station (T1) abstains from random access to the slots <2> ~ <4> of Frame 3 and instead transmits data via the next slot <5>.

[0031]

Figure 4 shows the format of packet data transmitted to the reserved slot among the signals transmitted to the central station

(C) from the peripheral stations (T1), (T2), ... The reserved slot is assigned in a form obtained by linking multiple time slots (though the case of one is also conceivable).

[0032]

The packet data transmitted to the reserved slot are constituted by the overhead unit (OH) comprised of a preambling unit for reproducing carrier waves & clocks and a unique word unit, the field (ADRS), which shows the peripheral station address of the transmission source, the field (REQ), which shows the length of a requested reservation slot, the order No. (SEQ) for the packet transmitted by each peripheral station, the field (COUNT), which shows the number of data units included in said packet, the frame check sequence field (FCS1), which targets the span from the ADRS unit to the COUNT unit, the data unit (UNIT), in which a single message issued from a terminal is stored, dummy bits for matching the packet length with the length of a single time slot, redundancy bits (FEC) for correcting errors, and the guard time (GT), which serves a function of securing an interval with the packet to be transmitted onto the next slot.

[0033]

Such packet data transmitted to the reserved slot differ from the packet data transmitted based on the random access format shown in Figure 2 in the sense that the packet data transmitted to the reserved slot are capable of storing multiple data units. Put differently, multiple data units can be transmitted after only one header ranging from the OH unit to the FCS1 unit has been added to

them. The packet data transmitted to the reserved slot may include a maximum of 8 data units so long as they can be stored within the reserved slot.

[0034]

Next, Figure 5 shows a format pertaining to a datum which includes only one data unit (UNIT) among the packet data likewise transmitted onto the reserved slot from the peripheral stations (T1), (T2), ... to the central station (C). Such a format enables the transmission of a long message that covers several time slots as a single packet after only one header from the OH unit to the FCS1 unit has been added it without dividing it. The format of this case is utterly identical to the packet format shown in Figure 2 from a constitutional standpoint other than the fact that the packet length is hereby equivalent to multiple time slots.

[0035]

Figure 6 shows a format pertaining to packet data among the signals transmitted from the central station (C) to the peripheral stations (T1), (T2), ... The packet data transmitted from the central station (C) are classified into three types, namely a user data packet, a reserved slot assignment individual information packet, and a reserved slot reception response packet. Each data comply with the high-level data link control (HDLC) frame format and are sandwiched between flag patterns (F) that respectively express the top and end of the packets.

[0036]

The user data packet is a packet which serves a function of transmitting, to the peripheral station side, data generated from a host terminal connected to the central station (C). The user data packet is constituted by the destination peripheral station address (ADRS), the sign (ID), which identifies itself as a user data packet, the data unit (DATA), in which the data generated from the host terminal are stored, and the frame check sequence (FCS), which detects transmission errors.

[0037]

The reserved slot assignment individual information packet is a packet which serves a function of assigning reserved slots to individual peripheral stations. The reserved slot assignment individual information packet is constituted by the peripheral station address (ADRS), which assigns a reserved slot, the sign (ID), which identifies itself as a reserved slot assignment individual information packet, the frame No. (FR) & slot No. (SL), which collectively show the inaugural time slot of the assigned reserved slot, the slot number (NS), which expresses the number of time slots beginning from said inaugural time slot that represent the reserved slot, and the frame check sequence (FCS), which serves a function of detecting transmission errors.

[0038]

The reserved slot reception response packet is a packet which serves a function of transmitting a reception response signal corresponding to the data transmitted onto the reserved slot by the peripheral stations (T1), (T2), ... The reception response

signal is constituted by the destination peripheral station address (ADRS), the sign (ID), which identifies itself as a reserved /6
slot reception response packet, the order No. designated on [SEQ] packet for confirming the reception of this reception response packet, the field (COUNT), which expresses the number of units included in the packet for confirming the reception of this reception response packet, the field (ACK), which expresses sets of information that confirm the receptions of the individual data units, and the frame check sequence (FCS).

[0039]

Of these, the reception confirmation information (ACK) is 1-byte information whereby 1 bit thereof expresses the confirmation of the reception of a single data unit. A case where the receptions of three data units are confirmed is instantiated in the example of Figure 6, and in this case, only 3 bits of the reception confirmation information (ACK) are effective. It is shown in this example that, although the first two of the three data units transmitted onto a single reserved slot from a given peripheral station were normally received, the last single data unit was discarded due to the detection of a transmission error therein.

[0040]

Figure 7 is a constitutional diagram pertaining to the central station (C). The transmission and/or reception device (1) engages in transmission and/or reception actions with the

satellite (S) and executes the frequency conversion of high-frequency/medium-frequency bands. The reception unit (2) demodulates the signals received by the transmission and/or reception device (1) and corrects errors.

[0041]

The channel monitor unit (3) detects, by referring to the frame check sequence field (FCS1) of the received packet, transmission errors of the received packet from the ADRS unit to the COUNT unit. In a case where an error has become detected, the prevailing packet is discarded. It identifies, with regard only to packets in which no errors have been detected, whether the prevailing data are data transmitted to normal time slots or data transmitted to reserved slots depending on whether "0" or a value other than "0" is being designated on them with reference to the COUNT unit and then relays the respectively identified data to the normal slot data processing unit (4) or the reserved slot data processing unit (5).

[0042]

The normal slot data processing unit (4) refers, first of all, to the assignment request reserved slot length (REQ) of the received packet, and then notifies, in a case where the length is not "0," the reserved slot assignment management unit (9) of the requested reserved slot length and the address of the requesting peripheral station.

[0043]

Secondly, the normal slot data processing unit (4) refers to the frame check sequence unit (FCS2) of the UNIT unit and detects the transmission errors of the UNIT unit. In a case where an error has become detected, the prevailing packet is discarded. In a case where no error has become detected, the PL unit, PC unit, and DATA unit of the UNIT unit are relayed to the reception data buffer (6), and at the same time, the normal slot reception response signal generation unit (7) becomes notified of the peripheral station address of the transmission source of this packet.

[0044]

The reserved slot data processing unit (5) refers, first of all, to the assignment request slot length (REQ) and then notifies, in a case where the length is not "0," the reserved slot assignment management unit (9) of the requested reserved slot length and the peripheral station address of the request source.

[0045]

Secondly, the reserved slot data processing unit (5) refers to the frame check sequence unit (FCS2) of each UNIT unit and detects transmission errors of the UNIT unit. In a case where an error has become detected, the prevailing UNIT unit is discarded. In a case where no error has become detected, the PL unit, PC unit, and DATA unit of each UNIT unit are relayed to the reception data buffer (6), and at the same time, the reserved slot reception response generation unit (8) becomes notified of the peripheral station address of the transmission source of this packet as well

as of its order No. and data reception information. The data reception information expresses the number of UNITs included in said packet and the identities of normally receiving UNITs.

[0046]

The reception data buffer (6) buffers the respective UNIT units received from the normal slot data processing unit (4) and the reserved slot data processing unit (5) and reassembles the data divided into packets at the peripheral stations into a singular datum once again by referring to the packet effective length (PL) and the packet reassembly information (PC) and relay the data which have not been divided into packets directly to the host terminal.

[0047]

The normal slot reception response signal generation unit (7) formulates a reception response signal by using the transmission source peripheral station address received from the normal slot data processing unit (4). Upon the arrival of the transmission timing of a frame timing signal, furthermore, it outputs said signal to the multiplexing unit (14).

[0048]

The reserved slot reception response generation unit (8) formulates a reserved slot reception response packet by using the transmission source peripheral station address, order No., and data reception information received from the reserved slot data processing unit (5) and then outputs the same to the multiplexing unit (14).

[0049]

The reserved slot assignment management unit (9) formulates a slot assignment table by using the requested reserved slot lengths and request source peripheral station addresses notified by the normal slot data processing unit (4) and the reserved slot data processing unit (5). It requests the individual/broadcast slot assignment information generation unit (10), furthermore, to issue reserved slot assignment individual information to each peripheral station and notifies the same of the assigned slots and the peripheral station address of the assignment destination.

[0050]

The individual/broadcast slot assignment information generation unit (10) formulates a reserved slot assignment individual information packet based on the request issued from the reserved slot assignment management unit (9) and then outputs the same to the multiplexing unit (14). Upon the arrival of the transmission timing of the frame timing signal, furthermore, the individual/broadcast slot assignment information generation unit (10) decodes the slot assignment equivalent to a single frame from the slot assignment table managed by the reserved slot assignment management unit (9) and then outputs the same to the multiplexing unit (14) as slot assignment broadcast information.

[0051]

The transmission data buffer (11) buffers the user data received by the host terminal, edits them into user data packets

of certain formats, and then outputs them to the multiplexing unit (14).

[0052]

The frame timing signal generation unit (12) outputs the frame timing signal that shows the boundaries of the frame to the multiplexing unit (14). At the same time, the frame timing signal

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generation unit (12) notifies the reception slot timing generation unit (13) of the reception frame timing used at the central station (C).

[0053]

The reception slot timing generation unit (13) formulates the reception slot timing used at the central station (C) based on the output of the frame timing signal generation unit (12) and then outputs the same to the channel monitor unit (3) and the normal slot reception response signal generation unit (7).

[0054]

The multiplexing unit (14) time-divides and multiplexes the respective outputs of the normal slot reception response signal generation unit (7), the reserved slot reception response generation unit (8), the individual/broadcast slot assignment information generation unit (10), the transmission data buffer (11), and the frame timing signal generation unit (12) and then outputs the same to the transmission unit (15).

[0055]

The transmission unit (15) adds redundancy bits for detecting transmission errors based on the CRC format to the packet data among the inputs received from the transmission unit (14) and then outputs the coded & modulated results to the transmission and/or reception device (1).

[0056]

Figure 8 is a constitutional diagram pertaining to the peripheral stations (T1), (T2), ... The transmission and/or reception device (16) transmits and/or receives signals via the satellite (S) and executes the frequency conversion of high-frequency/medium-frequency bands. The reception unit (17) demodulates the signals received by the transmission and/or reception device (16) and/or corrects errors therein and then outputs the processed signals to the separation unit (18).

[0057]

The separation unit (18) detects the frame timing signal generated by the central station (C) from among the outputs received from the reception unit (17) and then outputs the frame timing to the frame synchronicity unit (21), the slot assignment broadcast information to the reserved slot assignment management unit (28), the reception response signal to the delivery confirmation unit (29), and the packet data to the identification unit (19).

[0058]

The identification unit (19) detects errors in the user data received from the separation unit (18) and then judges, as valid

reception data, only the data unaccompanied by transmission errors and addressed to its own station and discards all other packet data. The identification unit (19), furthermore, acknowledges the types of packet data by referring to the ID unit of the valid reception data and then relays the user data packets to the reception data buffer (20), the reserved slot assignment individual information to the reserved slot assignment management unit (28), and the reserved slot reception response packet to the delivery confirmation unit (29).

[0059]

The reception data buffer (20) buffers the user data packet received from the identification unit (19) and then relays its DATA unit alone to the user data terminal.

[0060]

The frame synchronicity unit (21) determines, by taking into consideration the distance between its own station and satellite by using, as a standard, the frame timing transmitted from the central station (C), the frame timing used during the transmission of its own station and then outputs the determination results to the slot timing generation unit (22).

[0061]

The slot timing generation unit (22) divides the frame formulated by the frame synchronicity unit (21) into a certain number of slots and then determines the slot timing.

[0062]

The packeting unit (23) receives data from the user data terminal, and in a case where the lengths of such data are each short enough to be stored in the DATA unit of a single time slot, the packet reassembly information (PC), the data length (PL), and the frame check sequence unit (FCS2) are added to them for formulating a single UNIT unit.

[0063]

In a case where the lengths of such data are each not short enough to be stored in the DATA unit of a single time slot, furthermore, the packeting unit (23) separates the top portion of such data over a length that can be stored in the DATA unit of a single time slot, based on which [said data] become separated into a pair, namely lead and follow, packets. The packet reassembly information (PC), the data length (PL), and the frame check sequence unit (FCS2), furthermore, are added to each of the lead packet and follow packet for formulating a single UNIT unit.

[0064]

Information which judges whether or not the prevailing data partially constitute data divided into packets and, if they indeed partially constitute the divided data, whether they represent the lead packet or follow packet may, for example, be conceived as the packet reassembly information (PC).

[0065]

The transmission data buffer (24) buffers the UNIT unit received from the packeting unit (23) and then outputs the same to the transmission control unit (26). At this time, the

transmission data buffer (24) separately buffers the UNIT unit to be transmitted onto a single time slot by means of random access, the UNIT unit to be transmitted onto the reserved slot, and the UNIT unit to be retransmitted due to a previous transmission failure.

[0066]

The transmission data buffer (24), furthermore, temporarily caches the UNIT unit outputted to the transmission control unit (26) for the purpose of confirming its delivery. Upon the reception of a retransmission/buffer release command signal from the delivery confirmation unit (29), furthermore, the UNIT unit the release of which from the cache buffer is being commanded is erased from the buffer, and the UNIT unit the retransmission of which is being commanded is buffered once again into a special buffer for retransmission.

[0067]

The reservation management unit (25) manages the number of UNIT units being buffered in the transmission data buffer (24) as reserved slot utility data as well as their individual lengths and determines the number of time units to be reserved.

[0068]

The transmission control unit (26) first judges, upon the notification of the arrival of the slot timing by receiving the output [from] the slot timing generation unit (22), whether said timing is a randomly accessible slot timing, a reserved slot timing assigned to its own station, or a reserved slot timing

assigned to another station by referring to the slot assignment table of the reserved slot assignment management unit (28).

[0069]

In a case where the pervasion of a randomly accessible slot timing has been judged, the transmission control unit (26) decodes, from the transmission data buffer, the lead member of UNITs that can be transmitted by means of random access, and after it has added the address of its own station (ADRS), requested reserved slot length (REQ), the order No. (SEQ), the COUNT unit, and the frame check sequence unit (FCS1) to the same, it outputs the modified data to the transmission unit (27). At this time, a value commanded by the reservation management unit /8 (25) is designated as the requested reserved slot length (REQ). Moreover, "0" is assumed to be invariably designated in the COUNT unit under the pervasion of a randomly accessible slot timing.

[0070]

In a case where the prevailing slot is a reserved slot assigned to its own station, the transmission control unit (26) decodes, from the transmission data buffer (24), the number of UNITs being buffered as reserved slot utility data that can be stored in said reserved slot. At this time, the number of UNIT units decoded by the transmission control unit (26) from the transmission data buffer (24) is assumed to be commanded by the reservation management unit (25). The transmission control unit (26) adds, to the decoded multiple UNIT units, the address (ADRS) of its own station, requested reserved slot length (REQ), the

order No. (SEQ), COUNT unit, and the frame check sequence unit (FCS1) and then outputs the modified data to the transmission unit (27). A value commanded by the reservation management unit (25) is designated as the requested reserved slot length (REQ). At this time, furthermore, the transmission control unit (26) informs the transmission unit (27) not only of the number of consecutive time slots for transmission but also of the carrier wave output time.

[0071]

In a case where the slot timing signifies the pervasion of a slot assigned to another station, the transmission control unit (26) refrains from the transmission of data via said slot.

[0072]

Finally, the transmission control unit (26) notifies the delivery confirmation unit (29), as a transmission history, of the identity of the time slot used for data transmission and of whether or not the transmission was based on the random access or reserved slot transmission mode.

[0073]

The transmission unit (27) adds dummy bits to the input received from the transmission control unit (26), codes and modulates the added data, adds error correction redundancy bits (FEC) to the same, and then outputs the modified data to the transmission and/or reception device (16).

[0074]

The reserved slot assignment management unit (28) formulates a slot assignment table with reference to the slot assignment broadcast information and reserved slot assignment individual information transmitted from the central station (C).

[0075]

Memorized in the delivery confirmation unit (29) are not only the identity of the time slot through which its own station has transmitted data in response to the reception of the output of the transmission control unit (26) but also whether or not the transmission was based on the random access or reserved slot transmission mode.

[0076]

First, as far as the packet data transmitted by means of random access are concerned, the respective reception response signals memorized in the delivery confirmation unit (29) and outputted from the separation unit (18) are compared, and whether the response to the time slot through which its own station has attempted to transmit data is the affirmative response ACK (acknowledged) or negative response NAK (not acknowledged). In other words, in a case where the reception response signal shows the address of its own station, the pervasion of the affirmative response ACK is judged, whereas in a case where the same shows all "0" or the address of another peripheral station, the pervasion of the negative response NAK is judged.

[0077]

Next, as far as the packet data transmitted to the reserved slot are concerned, ACK is judged with regard only to those the normal receptions of which have been confirmed by the reserved slot reception response transmitted, as a type of packet data, from the central station (C). Packet data which have failed to yield returns of reserved slot reception responses upon the expiration of a certain standby period are assumed to have been discarded on the central station side, and the pervasion of the NAK response is judged. It is conceivable, furthermore, for NAK responses to have been received by partial UNITs despite the returns of reserved slot reception responses.

[0078]

The delivery confirmation unit (29) commands the transmission data buffer (24) to retransmit UNITs that have received, as a response, the negative response NAK and to release UNITs that have received, as a response, the affirmative response ACK from the temporary cache buffer.

[0079]

Figure 9 shows the first application example of the access format of the present invention based on the satellite communications format. As far as the slot constitution of this example is concerned, five time slots are allocated to a single frame, whereas the satellite delay is assumed to be equivalent to a single time slot.

[0080]

The pervasion of line congestion is hereby judged within the peripheral station (T1), for a pair of retransmission data have arisen, and accordingly, the reservation mode is used. At this stage, the datum <1> must be retransmitted by means of random access for the purpose of requesting a reserved slot, whereas the datum must be transmitted upon the expiration of a standby period corresponding to a randomly selected number of sots for the purpose of avoiding secondary collisions, if possible. New data <4> and <5> have arisen from the terminal during this standby period. Said data <4> and <5> are data that can normally be transmitted by means of random access, but these data <4> and <5> are hereby assumed to be transmitted instead to reserved slots due to the current line congestion.

[0081]

Two slots are necessary for transmitting the retransmission datum <2> and new data <4> & <5>, and therefore, the peripheral stations (T1) adds the reservation request <2> to the datum <1> and then transmits the addition result by means of random access. Upon the assignment of a reserved slot, furthermore, the data <2>, <4>, & <5> are transmitted.

[0082]

The packet transmitted at this time includes three UNIT units. In contradistinction with a case where one UNIT is transmitted as one packet datum, which requires the use of three frames, it hereby suffices to use only two slots in that three UNITs are transmitted as one packet datum.

[0083]

Figure 10 shows the second application example of the access format of the present invention based on the satellite communications format. Since a long message has arisen within the peripheral station (T1), it is hereby divided into the lead packet <1>, which can be stored within one time slot, and the follow packet <2>. Three slots are necessary for transmitting the follow packet <2>, and therefore, the peripheral station (T1) transmits, by means of random access, the datum <1> to which the reservation request <3> has been added. Upon the assignment of the reserved slot, furthermore, the follow packet <2> is transmitted. In contradistinction with a case where this long message is divided equally into a data length that can be transmitted via a single time slot and where each is then transmitted as a single packet datum, which requires the use of five slots in total, only four slots are necessary in total in the case of this example.

[0084]

Figure 11 is a detailed diagram pertaining to the transmission data buffer (24) for peripheral stations. The transmission data buffer (24) for peripheral stations is constituted by the buffer /9

(1102), which buffers UNITs to be transmitted by means of random access, the buffer (1103), which buffers retransmission data which have previously failed to be transmitted, the buffer (1104), which buffers data UNITs to be transmitted to reserved slots, and the buffers (1105), (1106), & (1107), in which data UNITs which have

been transmitted from the respective buffers are temporarily cached in a reception confirmation standby state.

[0085]

Of the data inputted from the packeting unit (23), the follow packet of two packets obtained by dividing a long message is buffered in the reservation data buffer (1104).

[0086]

Short data which can be stored within a single time slot and the lead packet of two packets obtained by dividing a long message, on the other hand, are normally buffered in the random access data buffer (1102). These data may, however, be buffered in the reservation data buffer (1104) by switching the SW unit (1101). This is referred to as the "random access inhibition mode."

[0087]

The retransmission data buffer (1103) requests, upon the arising of two or more retransmission data, the SW unit (1101) to assume the random access control [sic: Presumably "inhibition"] mode.

[0088]

Three temporary cache buffers (1105), (1106), & (1107) either erase the temporarily cached data or transfer them into the retransmission data buffer in compliance with a command received from the delivery confirmation unit (29).

[0089]

In a case where all the data within the temporary cache buffer (1106) for retransmission data have become erased, namely a case where the receptions of all by the central station (C) have been confirmed and where no data remain within the retransmission data buffer (1103), the random access inhibition mode of the SW unit (1101) becomes cancelled, as a result of which normal actions become resumed.

[0090]

The retransmission data buffer (1103) and reservation data buffer (1104), furthermore, notify the reservation management unit (25) of the total number of UNITs being buffered in each buffer as well as the lengths of the respective UNITs.

[0091]

Figure 12 is a detailed diagram pertaining to the reservation management unit (25) for peripheral stations. The reservation management unit (25) is constituted by the management units (1201) & (1202), which manage the total number of UNITs and the lengths of the respective UNITs within the reservation data buffer (1104) and retransmission data buffer (1103) of the transmission data buffer (24), and the reserved slot length determination/data editing control unit (1203), which determines not only the length of the reserved slot requested by its own station based on said number of UNITs and UNIT lengths but also the number of UNITs to be transmitted onto a single reserved slot.

[0092]

The reserved slot length determination/data editing control unit (1203) notifies the transmission control unit (26) of the length of the requested reserved slot during the attempt of the latter to transmit data. At a temporal stage where the reserved slot has become assigned, furthermore, it notifies the transmission control unit (26) of the number of UNITs to be decoded from the reservation data buffer (1102) or retransmission data buffer (1103).

[0093]

The reserved slot assignment management unit (28), furthermore, notifies, upon the reception of a reserved slot assignment individual information packet from the central station (C), the reserved slot length determination/data editing control unit (1203) of the arrival of the assignment. The reserved slot length determination/data editing control unit (1203) judges, in a case where no reserved slot has been assigned upon the passage of a certain period since the issuing of the reservation request, that the reservation request has not been accepted and then issues a repeated reservation request.

[0094]

In this example, however, the issuing of the next reservation request is halted until a slot has become assigned in response to a previously transmitted reservation request.

[0095]

(Effects of the invention)

As Figure 9 shows, in a case where multiple data have come to collide with one another often due to line congestion and where multiple data have come to stagnate within a peripheral station, said data can be transmitted as a single packet by sharing a header unit, based on which the number of time slots to be used for transferring an invariable volume of data can be reduced, accompanied by an improved efficiency, in comparison with a format of the prior art wherein each datum uses a single slot as a single packet datum.

[0096]

As Figure 10 shows, furthermore, in a case where a message with a long data length has arisen within a peripheral station, it can be transmitted after only one header unit has been added to it by using several consecutive time slots, based on which the number of time slots to be used for transferring an invariable volume of data can be reduced, accompanied by an improved efficiency, in comparison with a format of the prior art wherein a long message is minutely divided by designating a single time slot as a transmission unit and where each individual [1 & 1] divided unit uses, as a single packet, a single slot.

Brief explanation of the figures

Figure 1: A diagram which shows the satellite communications network of an application example of the present invention.

Figure 2: A diagram which shows a format for signals directed from the peripheral stations (T1), (T2), ... toward the central

station (C) with regard to the satellite communications network of Figure 1.

Figure 3: A diagram which shows a format for signals directed from the central station (C) toward the peripheral stations (T1), (T2), ...

Figure 4: A diagram which shows a format for packets to be transmitted onto a reserved slot formed by linking multiple time slots among the signals directed from the peripheral stations (T1), (T2), ... toward the central station (C).

Figure 5: A diagram which shows another format for packets to be transmitted onto a reserved slot formed by linking multiple time slots among the signals directed from the peripheral stations (T1), (T2), ... toward the central station (C).

Figure 6: A diagram which shows a format for packet data among the signals directed from the central station (C) toward the peripheral stations (T1), (T2), ...

Figure 7: A constitutional diagram for the central station (C).

Figure 8: A constitutional diagram for the peripheral stations (T1), (T2), ...

Figure 9: A time chart which shows an application example of the access format of the present invention.

Figure 10: A time chart which shows another application example of the access format of the present invention.

/10

Figure 11: A detailed diagram pertaining to a transmission data buffer which represents one constituent element of a peripheral station.

Figure 12: A detailed diagram pertaining to a reservation management unit which represents another constituent element of the peripheral station.

Figure 13: A time chart which shows an example of access formats of the prior art.

Figure 14: A time chart which shows another example of access formats of the prior art.

Figure 15: A time chart which shows still another example of access formats of the prior art.

Figure 16: A diagram which shows the relationships of the transmission frame timing on the peripheral station side of the present invention with the transmission response signal and slot assignment broadcast information transmitted by the central station.

(Explanation of notations)

(C): Central station;

(S): Satellite;

(T1), (T2), and (T3): Peripheral stations;

(1) and (16):

(2) and (17): Reception units;

(3): Channel monitor unit;

(4): Normal slot data processing unit;

(5): Reserved slot data processing unit;

(6) and (20): Reception data buffers;

(7): Normal slot reception response signal generation unit;

(8): Reserved slot reception response generation unit;

(9) and (28): Reserved slot assignment management units;

(10): Individual/broadcast slot assignment information generation unit;

(11) and (24): Transmission data buffers;

(12): Frame timing signal generation unit;

(13): Reception slot timing generation unit;

(14): Multiplexing unit;

(15) and (27): Transmission units;

(18): Separation unit;

(19): Identification unit;

(21): Frame synchronicity unit;

(22): Slot timing generation unit;

(23): Packeting unit;

(25): Reservation management unit;

(26): Transmission control unit;

(29): Delivery confirmation unit.

Figure 1

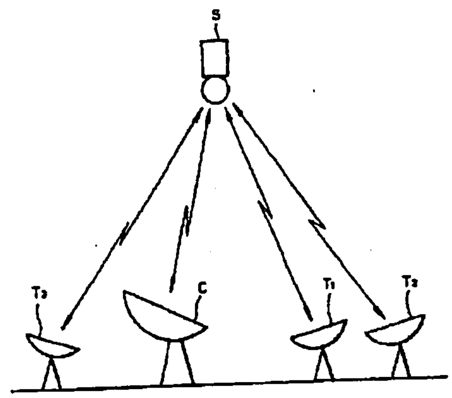
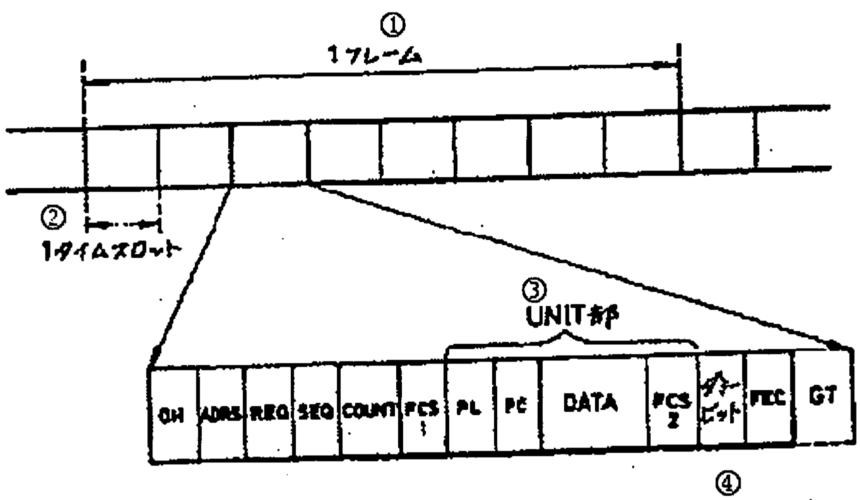
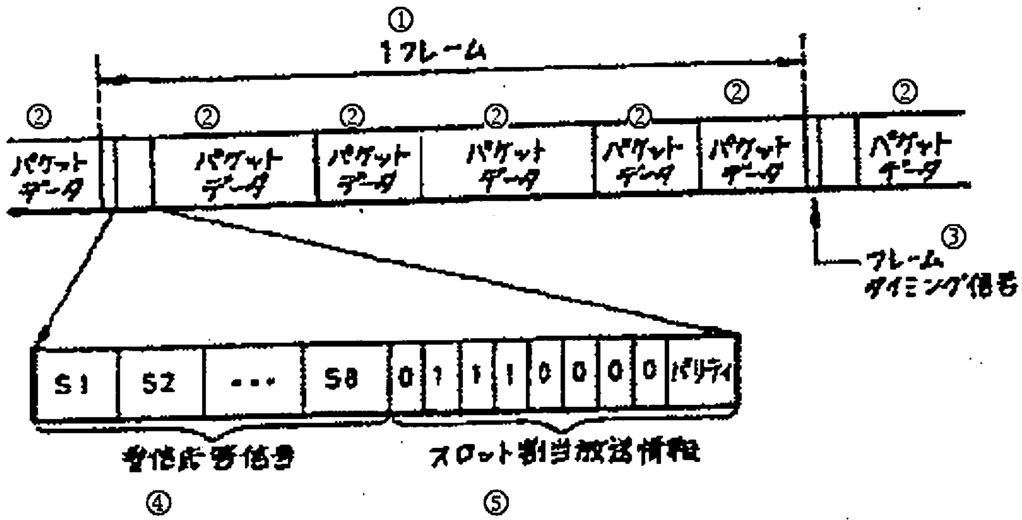


Figure 2



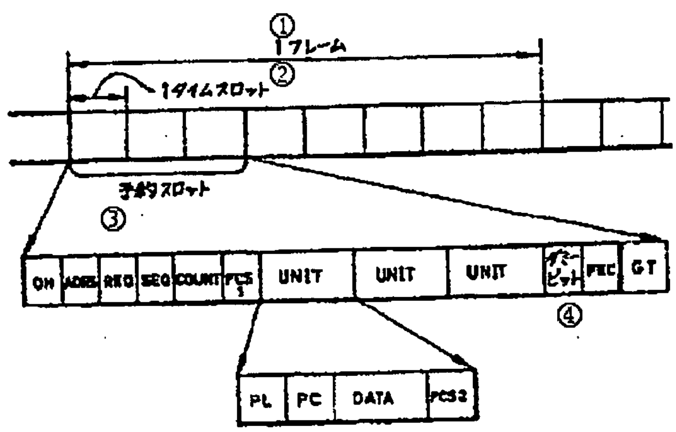
[(1): 1 frame; (2): 1 time slot; (3): UNIT unit; (4): Dummy bits]

Figure 3



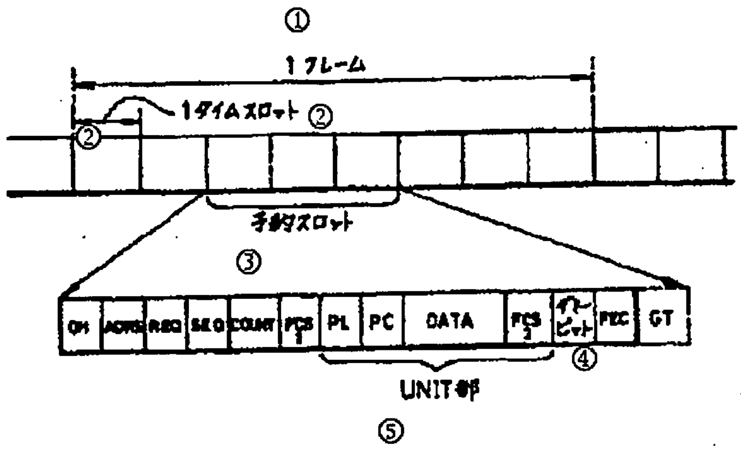
[(1): 1 frame; (2): Packet data; (3): Frame timing signal; (4): Reception response signal; (5): Slot assignment broadcast information]

Figure 4



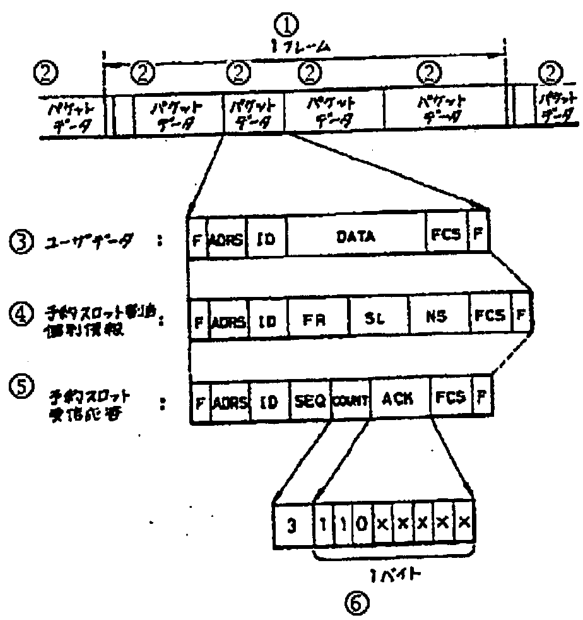
[(1): 1 frame; (2): 1 time slot; (3): Reserved slot; (4): Dummy bits]

Figure 5



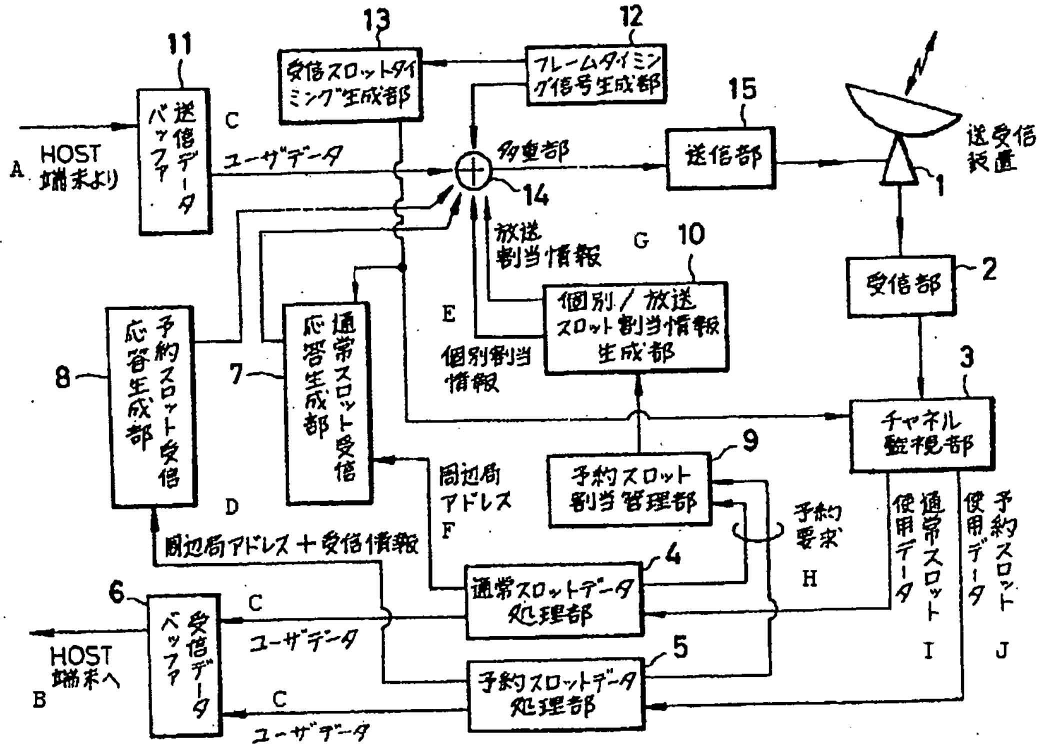
[(1): 1 frame; (2): 1 time slot; (3): Reserved slot; (4): Dummy bits; (5): UNIT unit]

Figure 6



[(1): 1 frame; (2): Packet data; (3): User data; (4): Reserved slot assignment individual information; (5): Reserved slot reception response; (6): 1 byte]

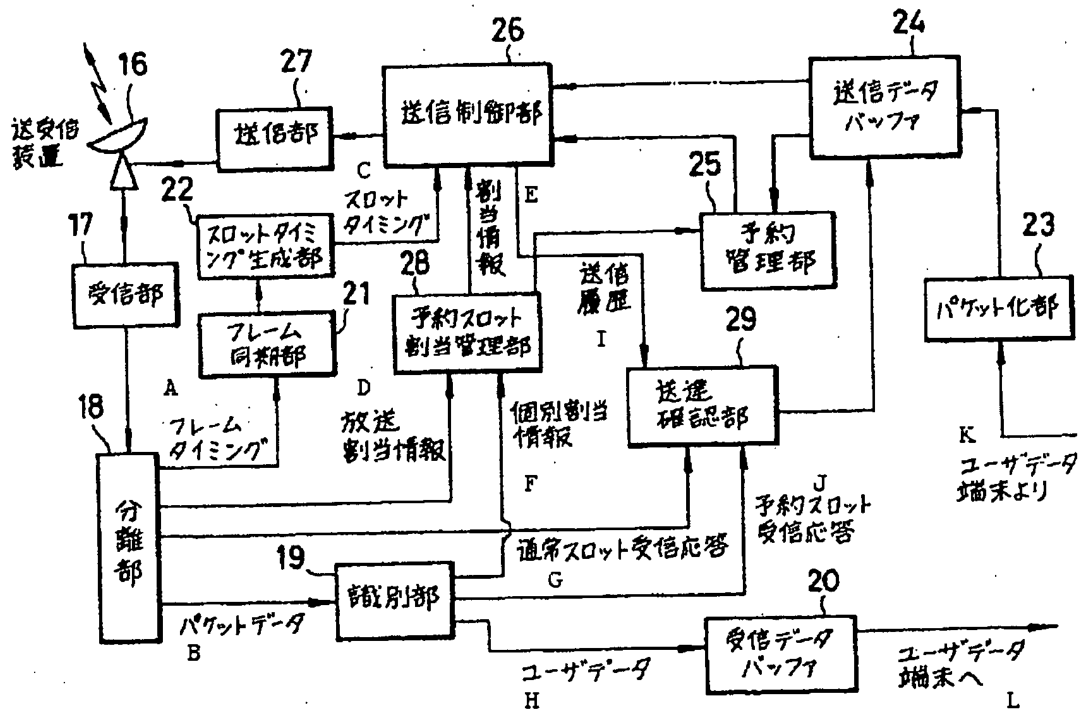
Figure 7



[(A): From HOST terminal; (B): To HOST terminal; (C): User data; (D): Peripheral station address + reception information; (E): Individual assignment information; (F): Peripheral station address; (G): Broadcast assignment information; (H): Reservation request; (I): Normal slot for utility data; (J): Reserved slot for utility data; (1): Transmission and/or reception device; (2): Reception unit; (3): Channel monitor unit; (4): Normal slot data processing unit; (5): Reserved slot data processing unit; (6): Reception data buffer; (7): Normal slot reception response signal generation unit; (8): Reserved slot reception response generation unit; (9): Reserved slot assignment management unit; (10): Individual/broadcast slot assignment information generation unit;

(11): Transmission data buffer; (12): Frame timing signal generation unit; (13): Reception slot timing generation unit; (14): Multiplexing unit; (15): Transmission unit]

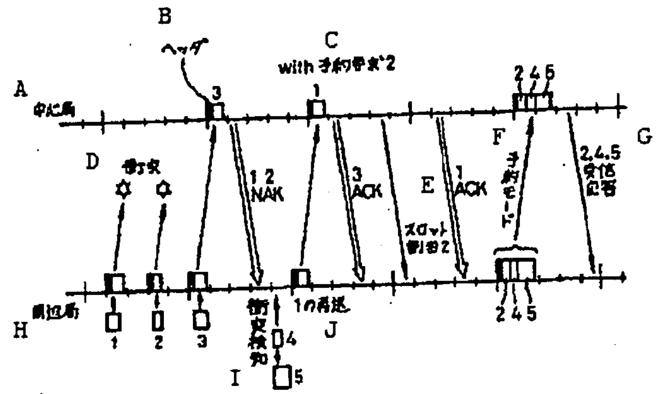
Figure 8 /12



[(A): Frame timing; (B): Packet data; (C): Slot timing; (D): Broadcast assignment information; (E): Assignment information; (F): Individual assignment information; (G): Normal slot reception response; (H): User data; (I): Transmission history; (J): Reserved slot reception response; (K): From user data terminal; (L): To user data terminal; (16): Transmission and/or reception device; (17): Reception unit; (18): Separation unit; (19): Identification unit; (20): Reception data buffer; (21): Frame synchronicity unit;

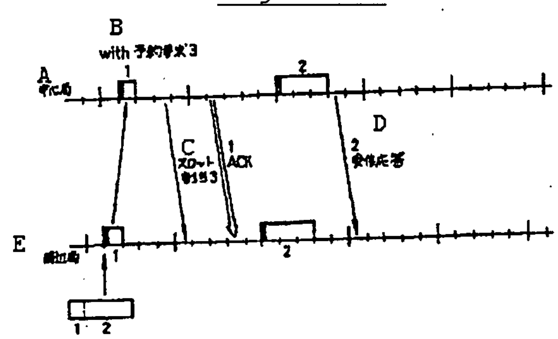
(22): Slot timing generation unit; (23): Packeting unit; (24): Transmission data buffer; (25): Reservation management unit; (26): Transmission control unit; (27): Transmission unit; (28): Reserved slot assignment management unit; (29): Delivery confirmation unit]

Figure 9



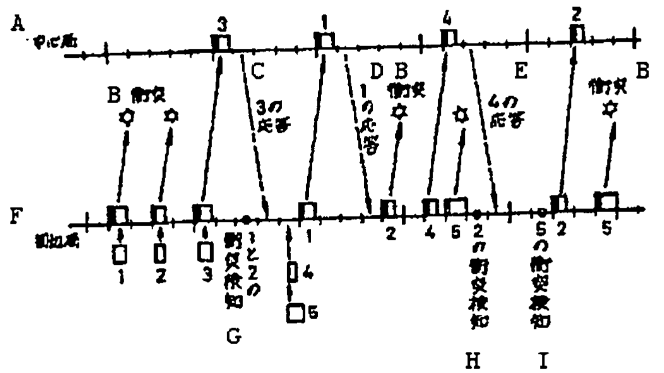
[(A): Central station; (B): Header; (C): With reservation request 2; (D): Collision; (E): Slot assignment of 2; (F): Reservation mode; (G): Reception responses to 2, 4, & 5; (H): Peripheral station; (I): Collision detection; (J): Retransmission of 1]

Figure 10



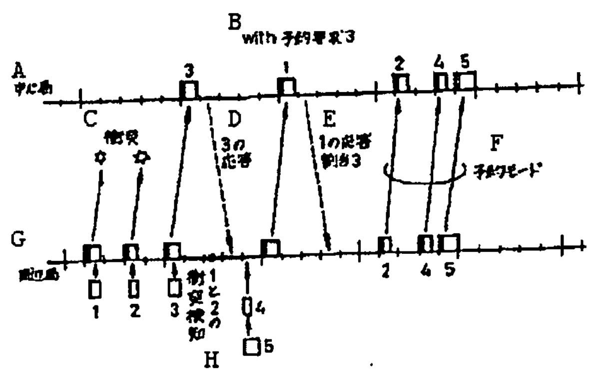
[(A): Central station; (B): With reservation request 3; (C): Slot assignment of 3; (D): Reception response to 2; (E): Peripheral station]

Figure 13



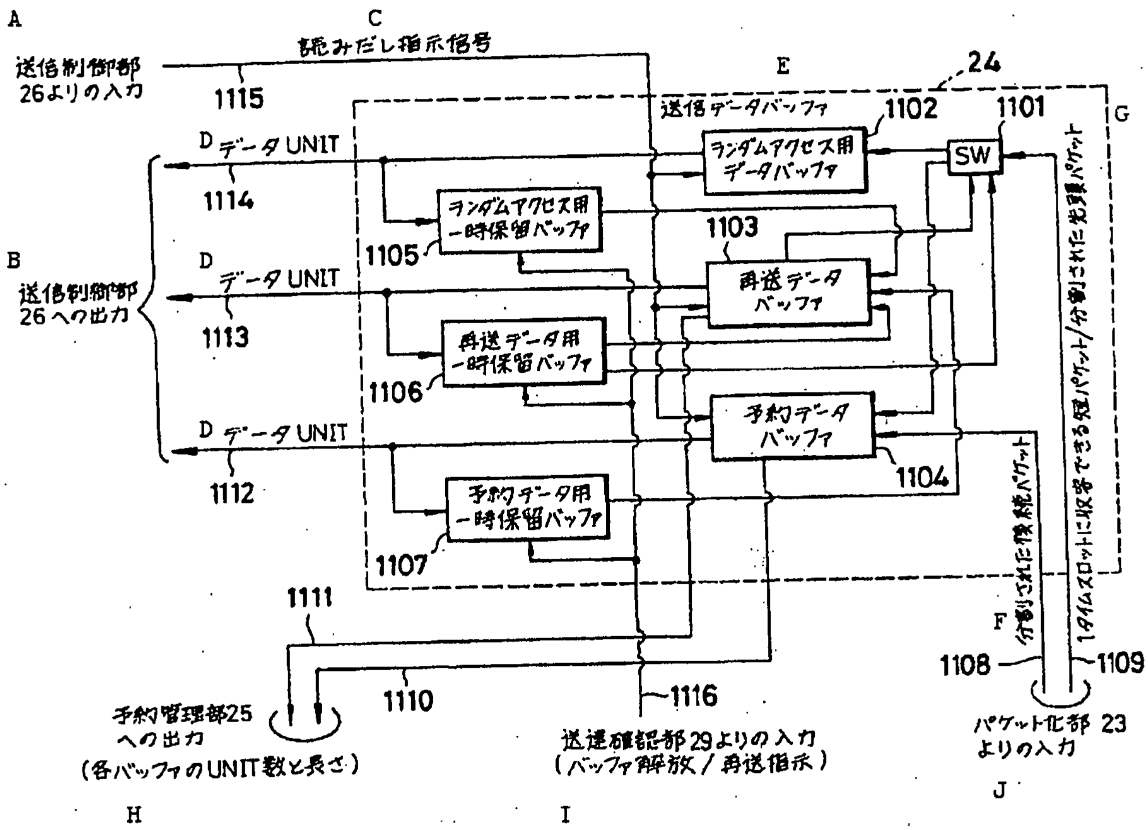
[(A): Central station; (B): Collision; (C): Response to 3; (D): Response to 1; (E): Response to 4; (F): Peripheral station; (G): Collision detection of 1 & 2; (H): Collision detection of 2; (I): Collision detection of 5]

Figure 14



[(A): Central station; (B): With reservation request 3; (C): Collision; (D): Response to 3; (E): Response to 1 & assignment of 3; (F): Reservation mode; (G): Peripheral station; (H): Collision detection of 1 & 2]

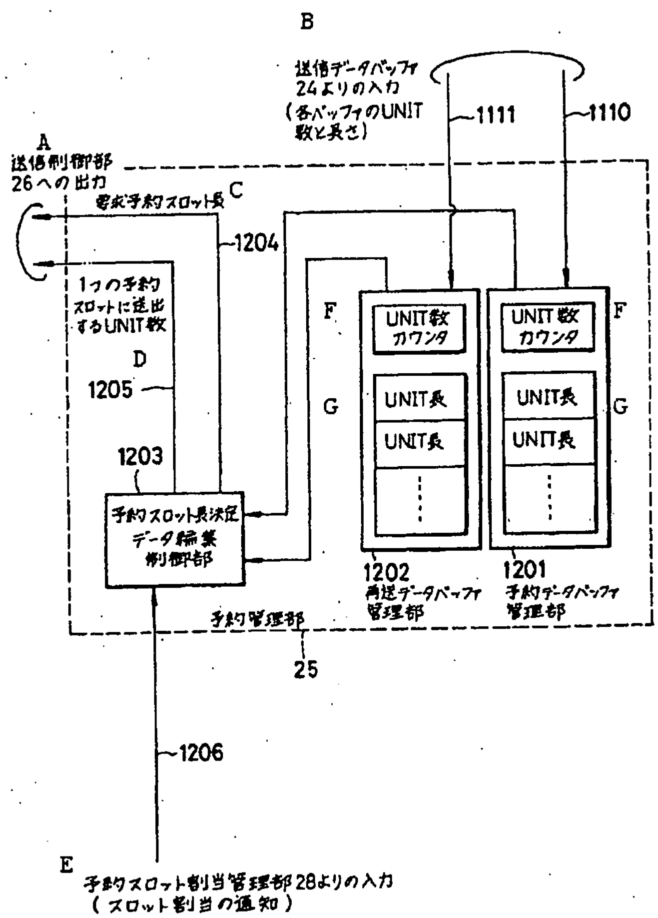
Figure 11 /13



[(A): Input from transmission control unit (26); (B): Output to transmission control unit (26); (C): Decoding command signal; (D): Data UNIT; (E): Transmission data buffer; (F): Follow packet obtained as a result of division; (G): Short packet that can be stored in 1 time slot/lead packet obtained as a result of division; (H): Output to reservation management unit (25) (UNIT unit and length of each buffer); (I): Input from delivery confirmation unit (29) (buffer release/retransmission command); (J): Input from packeting unit (23); (1102): Buffer for random access; (1103): Retransmission data buffer; (1104): Reservation data buffer; (1105): Temporary cache buffer for random access;

(1106): Temporary cache buffer for retransmission data; (1107): Temporary cache buffer for reservation data]

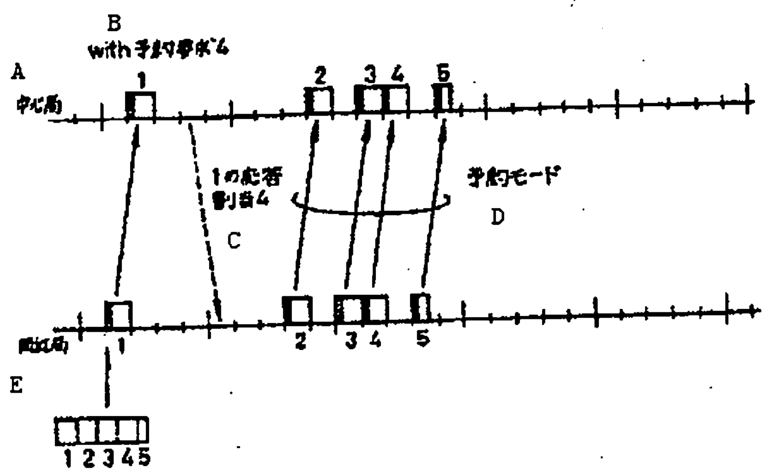
Figure 12 /14



[(A): Output to transmission control unit (26); (B): Input from transmission data buffer (24) (Unit number and length of each buffer); (C): Requested reserved slot length; (D): Number of UNITs transmitted to one reserved slot; (E): Input from reserved slot assignment management unit (28) (notification of slot assignment); (F): UNIT number counter; (G): UNIT length; (25): Reservation

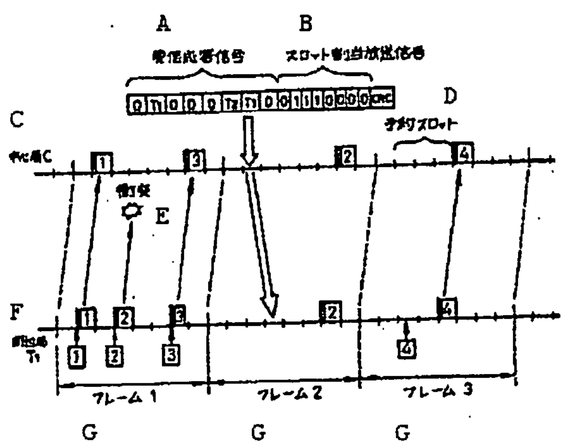
management unit; (1201): Reservation data buffer management unit; (1202): Retransmission data buffer management unit; (1203): Reserved slot length determination/data editing control unit]

Figure 15 /15



[(A): Central station; (B): With reservation request 4; (C): Response to 1 & assignment of 4; (D): Reservation mode; (E): Peripheral station]

Figure 16



[(A): Reception response signal; (B): Slot assignment broadcast signal; (C): Central station C; (D): Reserved slot; (E): Collision; (F): Peripheral station T1; (G): Frame]